An adaptive Energy-Efficient MAC protocol for wireless sensor network

Tijs van Dam, Koen Langendoen

Sensys 03

Outline

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  - Basic design
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Introduction

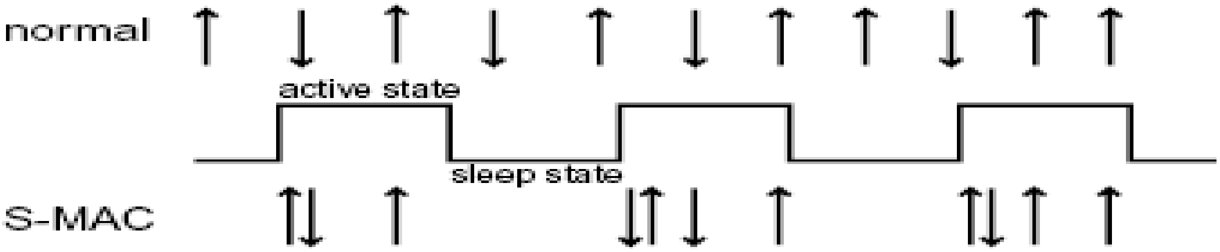
- In wireless networks, MAC protocols tries to ensure that no two nodes are interfering with each other's transmissions and deal with the situation when they do.
- In WSN, there are more constraints:
  - Battery-operated and hard to recharge
  - Many operations use much energy.
  - Fairness is not important.

T-MAC protocol design

- T-MAC (Timeout-MAC) is a contention-based MAC protocol.
- Unlike S-MAC (Scheduling-MAC) focusing on how to fairly allocate nodes' transmission, T-MAC mainly focuses on the minimization of idle listening and lets node sleeping as long as possible.

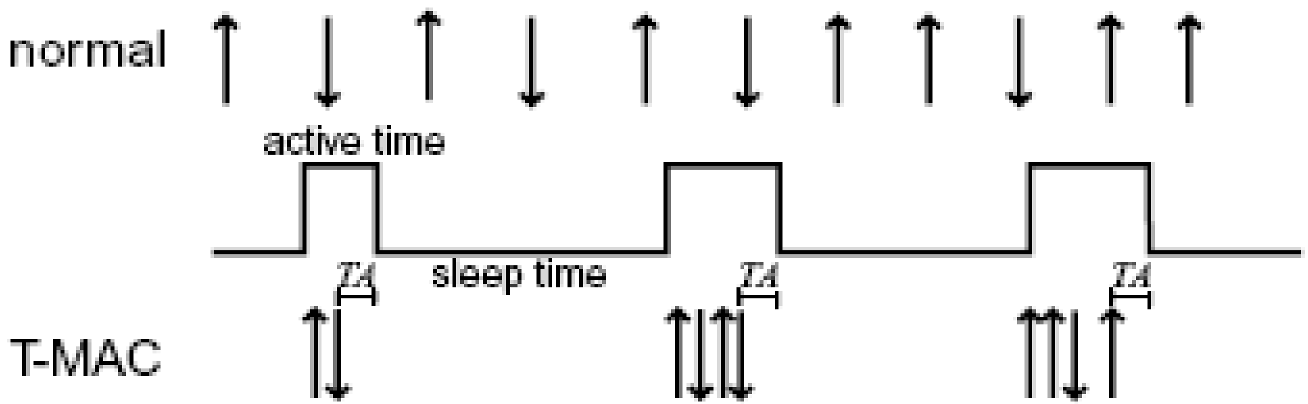
The disadvantages of S-MAC

- Since in sensor network ,the messages usually are very short and needs only 5ms to transmitting and receiving.
- Most of active time are doing nothing but idle listening in S-MAC.



Basic design

- The novel idea of the T-MAC is to reduce idle listening by transmitting all messages in bursts of variable length and sleeping between bursts



TA is a threshold to enter sleep mode.

Basic design

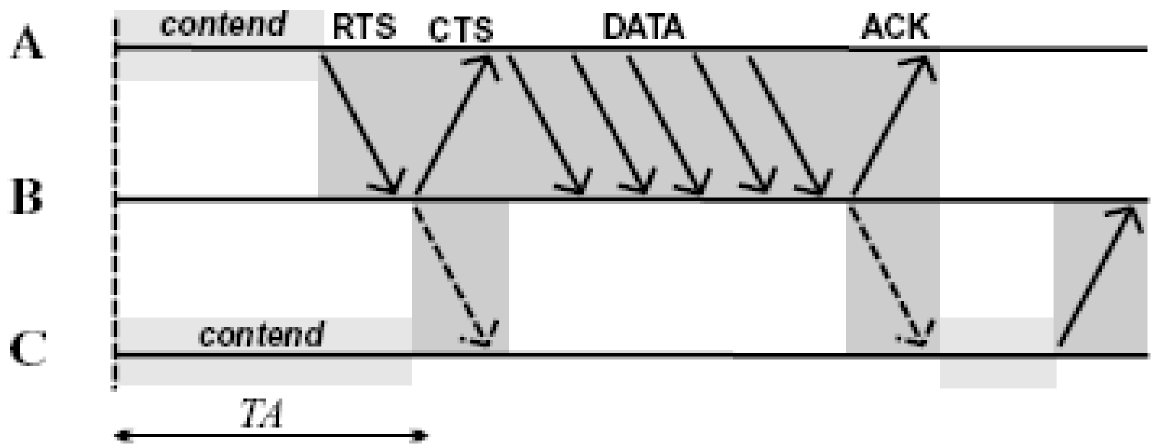
- The scheme is
  - Nodes periodically wakes up to communicate.
  - Messages are transmitted and received in a burst
  - New messages are queued.
- Thus the active time varies dynamically. Then nodes sleep until next cycle.

Basic design

- An active time ends when no **activation event** has occurred for a time **TA**.
- TA determines the min idle time.
- An activation event is:
  - the firing of a periodic frame timer;
  - the reception of any data on the radio;
  - the sensing of communication on the radio, e.g. during a collision;
  - the end-of-transmission of a node's own data packet or acknowledgement;
  - the knowledge, through overhearing prior RTS and CTS packets, that a data exchange of a neighbor has ended.

RTS operation

- Unlike random back-off in IEEE802.11, in T-MAC, a RTS starts by waiting and listening for a random time within a **fixed contention interval**.



RTS operation

- RTS retires: when a node send a RTS and received no CTS, something happens:
  1. the receiving node has not heard the RTS due to collision ;or
  2. the receiving node is prohibited from replying due to an overheard RTS or CTS; or
  3. the receiving node is asleep.
- If a node retry by sending RTS and receives no answer twice, it should go to sleep
- The messages will be queued until next chance.

Choosing TA

- A node shouldn't go to sleep while its neighbors are still communicating.
- Receiving a RTS or CTS from a neighbor can trigger a renewed interval TA.
- So TA must long enough to receive a CTS .

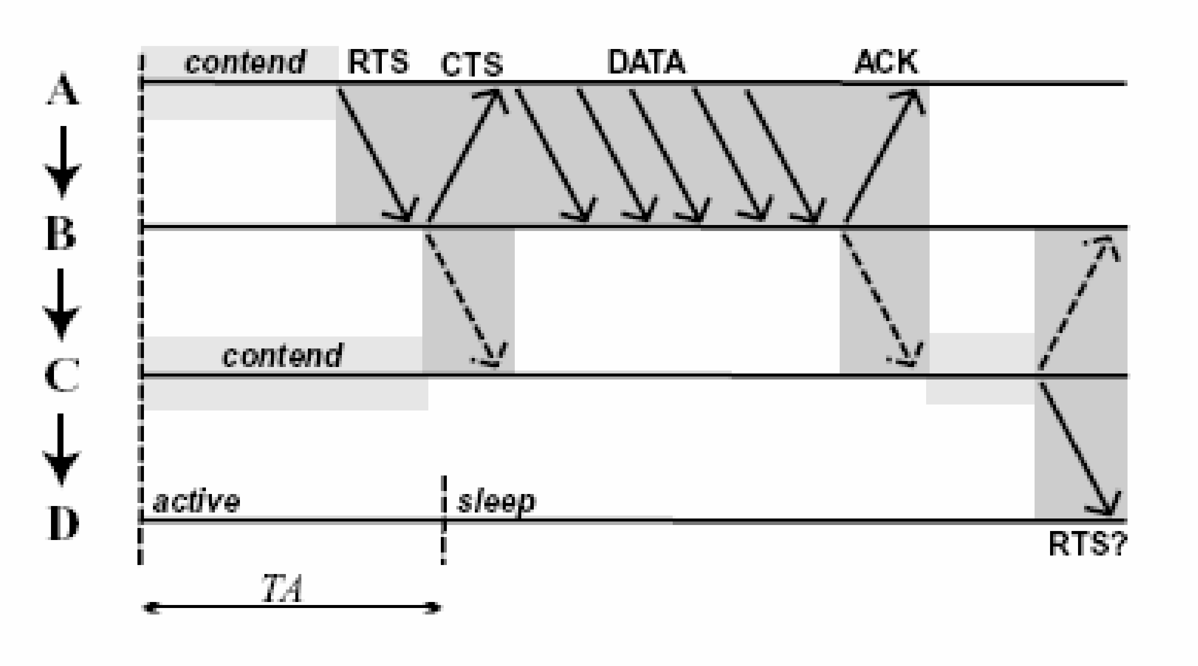
$$TA > C + R + T$$

C: the length of contention interval
R: the length of RTS packet
T: the turn around time

- TA = 1.5(C+R+T) is proved to be satisfactory.

Early sleeping problem

- Under the scheme, the early sleeping problem may occur in the nodes-to-sink communication.

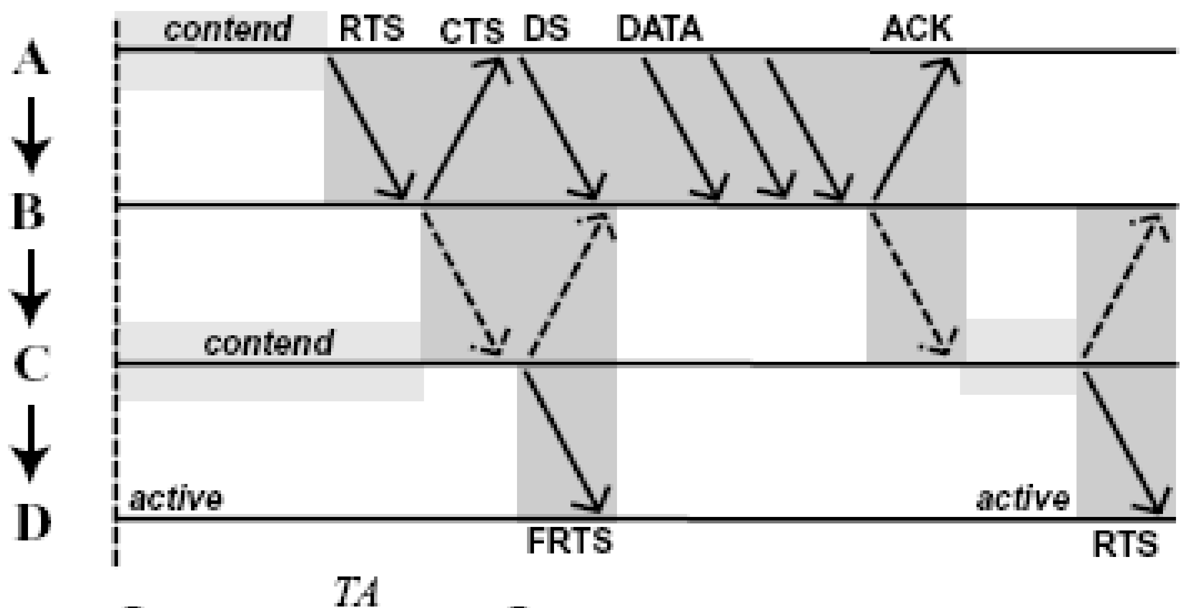


Early sleeping problem

- According to above figure, only 50% probability node C can send to D a single packet ,and 25% for two packets.
- The problem reduced the total throughput of T-MAC to less than half of the max throughput of S-MAC.

Early sleep problem

- Solutions:
  - Future request-to-send(FRTS)

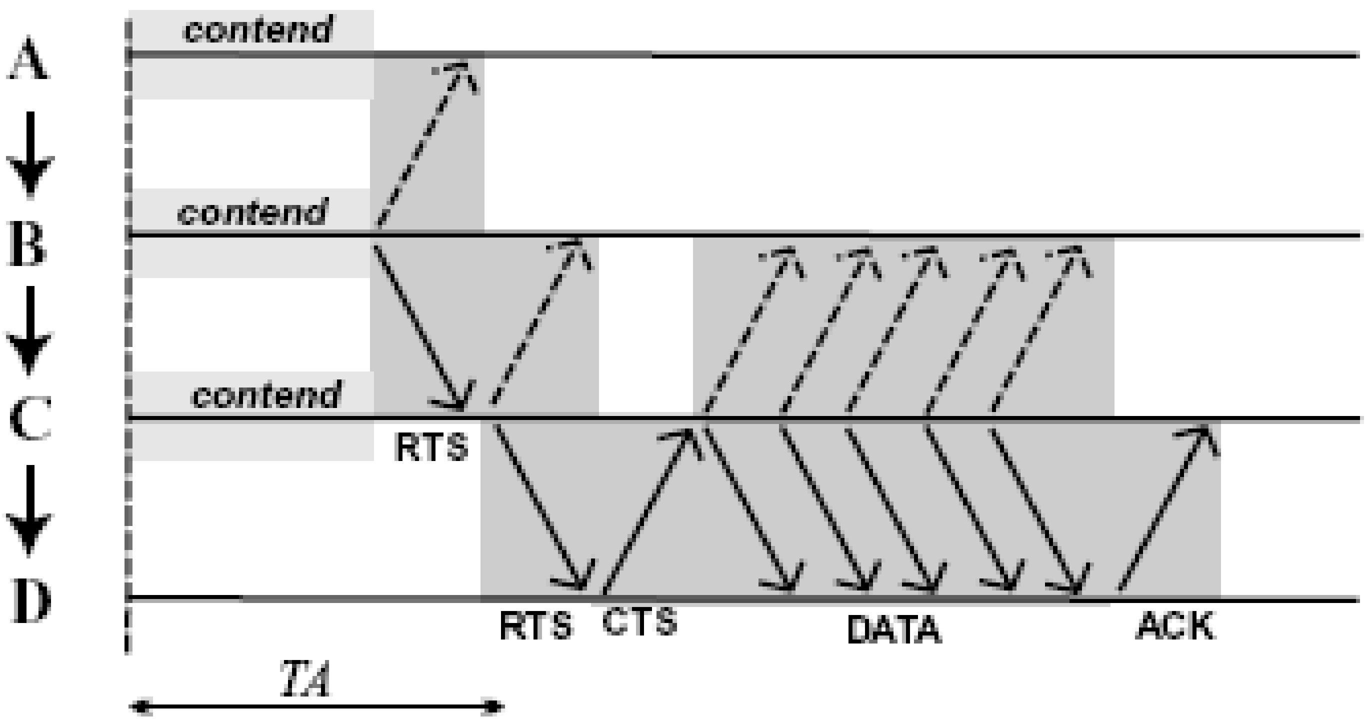


Future request-to-send(FRTS)

- Node C overhears a CTS packet destined for another node, it sends FRTS packet contains the length of the blocking data communication.
- Node D receives FRTS packet and would be active that time.
- To prevent any other node from taking the channel ,node A sends a small data-send(DS) packet. Since DS and FRTS may collide ,but it's OK.

Early sleep problem

- Taking priority on full buffers

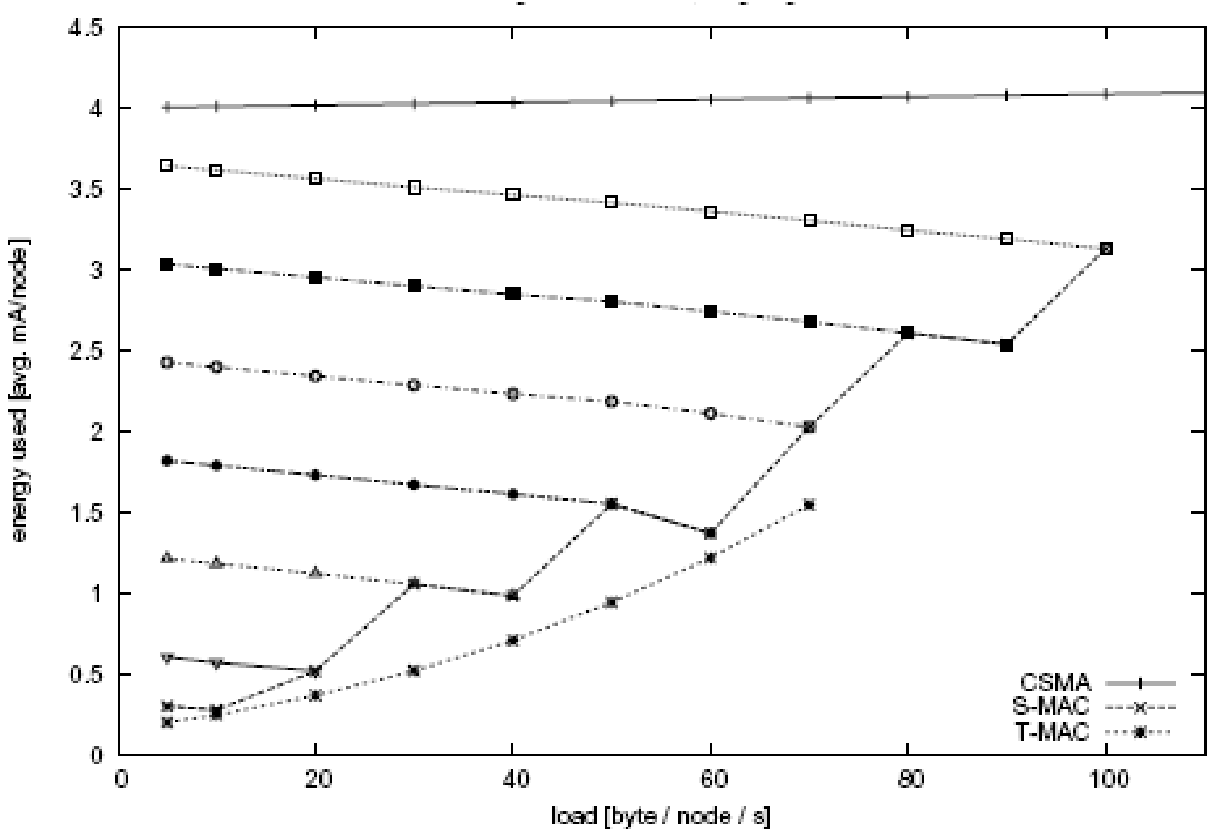


Taking priority on full buffers

- When a node's buffer is almost full ,it may prefer sending to receiving.
- When the node received a RTS, it immediately sends its own RTS. Then it has a higher chance to transmit.
- The method is like flow control scheme.

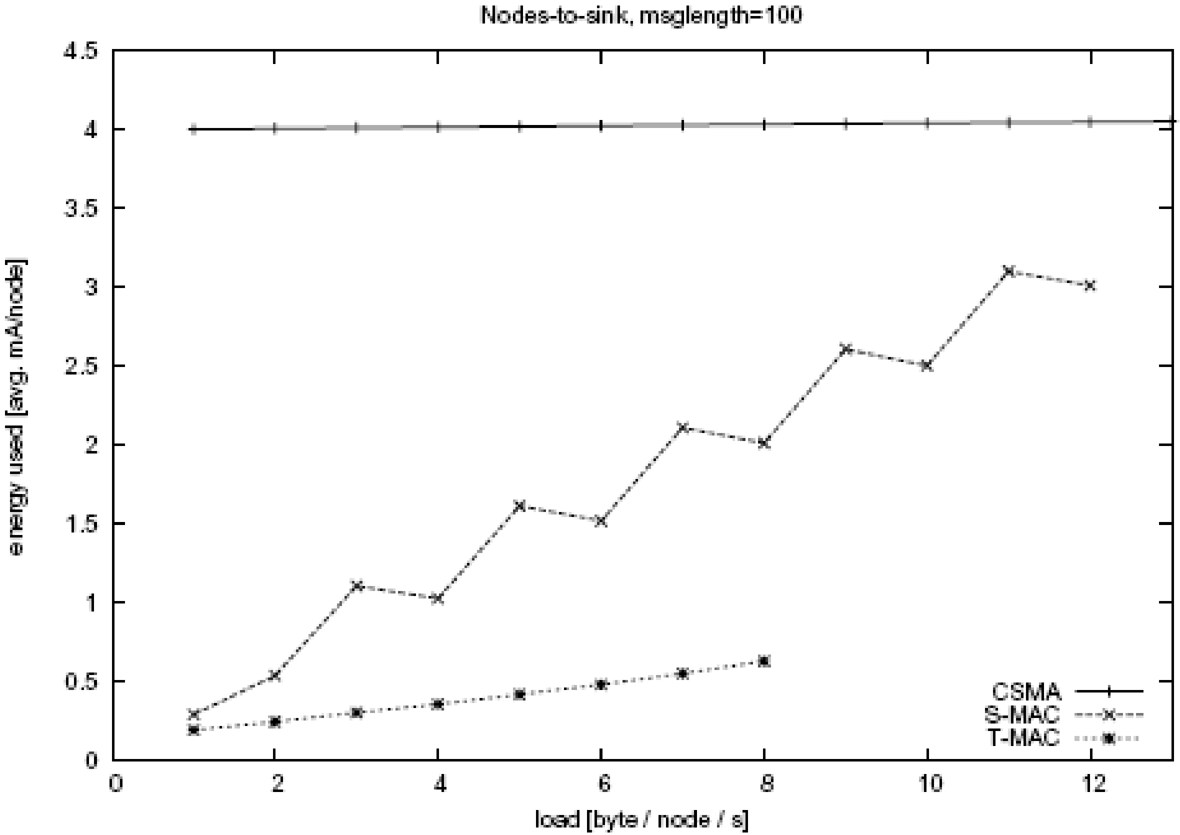
Simulation and result

- Unicast scenario

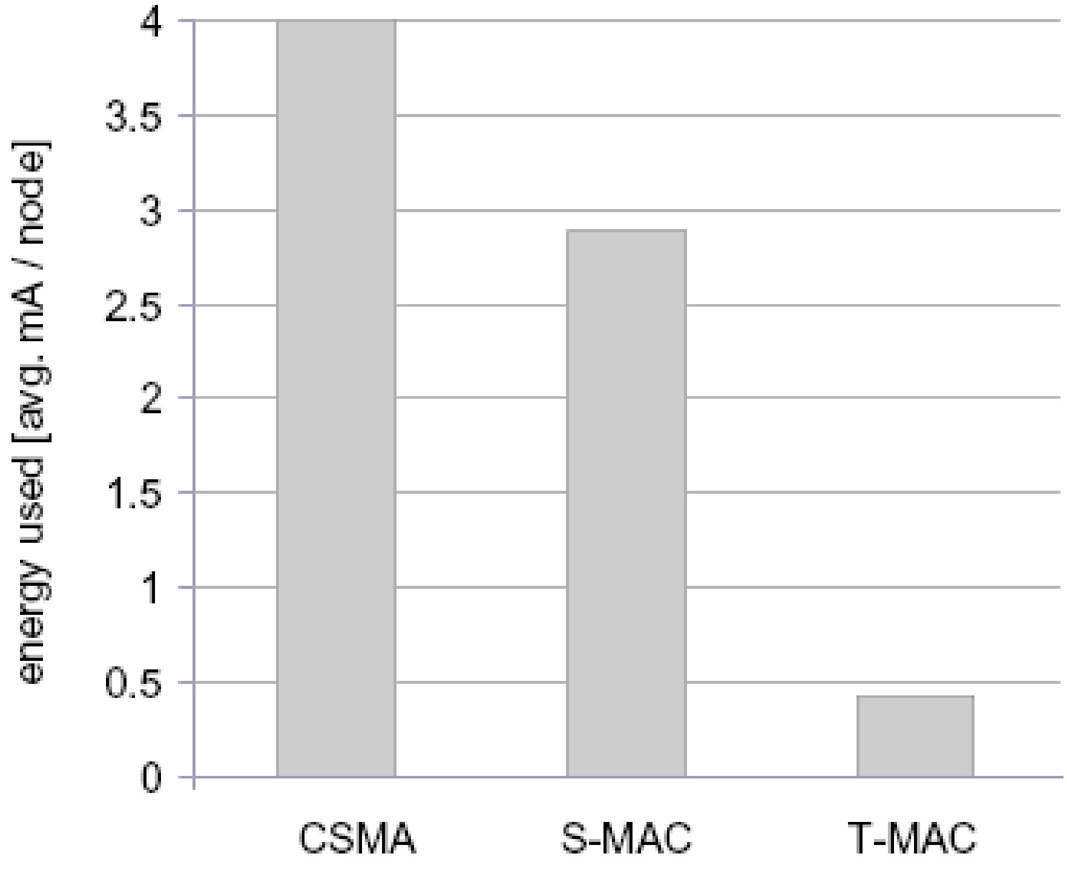


Simulation and result

- Nodes-to-sink scenario



Simulation and result

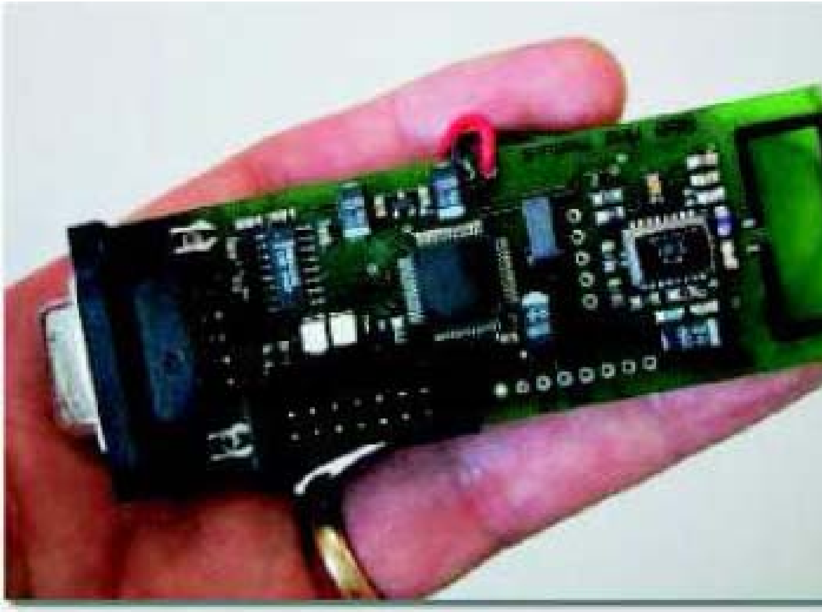


Conclusion

- T-MAC is a protocol dynamically adapting a listen/sleep duty cycle in a novel way ,through fine-grained timeouts.
- In a sample scenario with variable load, T-MAC outperforms S-MAC by a factor of 5.
- Idle listening wastes a greater part of energy than we can consider.
- A better MAC protocol is a good issue for power saving research.

EYES sensor node

- Texas Instruments MSP430F149 processor with 2KB RAM
- 60KB Flash memory; the
- 16 bit processor runs at a variable clock rate
- communicate using a 115 kbps radio (RFM TR1001, 868.35MHz, hybrid transceiver),
- 2Mb EEPROM memory (AST 25P20V6).
- interfaces including JTAG, RS232, 2 LEDs, and 16 general purpose I/O pins (8 with ADC capability). The
- 3V supplied by two AA batteries



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